3.0 RECYCLED URANIUM MASS FLOW

3.1 Uranium Recycle Description

The ICPP received spent fuel from propulsion reactors, DOE test reactors, foreign reactors under the Atoms for Peace Program, and from university reactors. The burnup on these fuel materials ranged from zero (or very low burnup) to high burnups on some of the reactor development fuel. The reactor fuels were primarily from light water reactors but included fast breeder reactor fuels as well. The beginning of life enrichment of the fuels processed ranged from 50% to 97%. The average end-of-life enrichment for the non-classified fuels was approximately 78%.

After the uranium was recovered by the ICPP processes, the fuel was shipped to Y-12 or Portsmouth for additional processing and for recycling into the complex inventory or it was shipped to Rocky Flats, Pacific Northwest National Laboratory, or Los Alamos National Laboratory where it was used for criticality experiments in their physics program.

3.2 Uranium Receipts

Recycled uranium was received at ICPP from Y-12 in 1971 in the form of UO_3 prepared in their rotary kiln denitrator. This material was used for the startup bed for the denitrator to begin processing the 50% enriched uranium product. The amount of uranium received was 20.648 Kgs and was shipped to out with the first batch of denitrated uranium product. Details on the contaminants in this material are unknown although it is believed to be material that had been shipped to Y-12 from ICPP then run through their process to make the particulate UO_3 needed for the initial denitrator bed.

A second shipment was received in 1978. It was a partial return of the material that had been shipped to PNNL for criticality experiments earlier in 1978 and consisted of 28.064 Kgs of recycled uranium. It was returned to the process inventory, run through the hexone extraction cycles, then denitrated before being shipped out with similar product to Y-12. This material is the product that ICPP shipped to PNNL and as such the contaminants would be identical to the contaminants that were shipped.

3.3 Uranium Shipments

Uranium shipments from ICPP are shown in Table IV. The products were shipped to the Y-12 plant (24,773 Kgs) for purification and preparation of metal for use as driver fuel for the Savannah River production reactors. 4,076 Kgs were sent to Portsmouth for re-enrichment and recycling into the DOE complex reactors. In addition, small quantities were shipped to other complex sites for use in criticality experiments: 47 Kgs to the Pacific Northwest National Laboratory,

168 Kgs to Los Alamos National Laboratory, and 219 Kgs to Rocky Flats. Shipping data giving dates and locations where the shipment was sent are also shown in Table IV.

The listing of fuel processed at ICPP, (see Table V) is based on the spent fuel shipper data, which is the as-fabricated (or "before burnup") value. This value was deliberately chosen for the input value because of criticality concerns. "Burnup" of specific fuel elements in a core is a function of their location in the core. By using the "before burnup" value for the uranium, a credible, conservative assessment of criticality risk can be made. Once the fuel is in solution, an accurate measurement of the uranium and the fissile content can be made.

The accountability tank is where the samples are taken for the input accountability measurements. These values are then used through the rest of the process as the basis for the criticality calculations.

The final accountability measurement is made after the uranium passes through all of the extraction cycles and the final product is packaged. Samples are then taken from each of the shipping containers. The measurements made on each of the samples is an isotope dilution mass spectrometry measurement where an accurately measured aliquot containing a precisely known amount of U-233 is added to the sample as a calibration standard. This method provides accurate and highly precise values of total uranium and uranium isotopic distribution.

The initial input values provided by the shipper do not take into account the U-235 consumed by the reactor. As a result, the amount of total uranium in the final product, (see Table IV), would be expected to be less than that charged to the dissolvers, as shown in Table V. Thus, the excess that is observed is the difference between the shippers values recorded as the material was charged to the dissolvers and the amounts measured at the point where the product packages were sealed for shipment.

Table IV

Shipments of Final Product

Year	741	No. Shipments	Destination	Total U
1953	CPI-CYT	8	Y-12	310,983 g
1954	CPI-CYT	7	Y-12	289,247
1955	(CPI-CYT	8	Y-12 742,669)	
	(CPI-SFJ	3	Rocky Flats 219,093)	961,762
1956	CPI-CYT	7	Y-12	1,122,452
1957	CPI-CYT	5	Y-12	611,851
1958	CPI-CYT	9	Y-12	2,683,680
1959	CPI-CYT	5	Y-12	1,763,087
1960	CPI-CYT	3	Y-12	579,649
1961	-	-	-	-
1962	CPI-CYT	8	Y-12	775,823
1963	CPI-CYT	3	Y-12	770,678
1964	JZA-FZB	2	Y-12	421,818
1965	JZA-FZB	4	Y-12	812,790
1966	JZA-FZB	3	Y-12	595,477
1967	-	-	-	-
1968	JWA-FZB	4	Y-12	821,403
1969	-	-	-	-
1970	JWA-FZB	4	Y-12	527,383
1971	(JWA-FZB	2	Y-12)	1,654,977
	(JSA-FZB	2	Y-12)	
1972	JSA-FZB	1	Y-12	434,476
1973	(JSA-FXA	4	Portsmouth 1,374,895)	
	(JSA-FZB	2	Y-12 552,835)	1,927,730
1974	JSA-FZB	1	Y-12	381,339
1975	(JSA-FZB	2	Y-12 898,009)	
	(JSA-FXA	3	Portsmouth 1,402,663)	2,300,672
1976	(JSA-FXA	3	Portsmouth 1,298,210)	
	(JSA-FZB	2	Y-12 519,582)	1,817,792
1977	JSA-FZB	2	Y-12	976,177
1978	(JSA-FZB	3	Y-12 526,966)	
	(JSA-HYA	2	PNNL 47,010)	573,976
1979	JSA-FZB	1	Y-12	543,976
1980	-	-	-	-
1981	JXI-FZB	2	Y-12	904,422
1982	JXI-FZB	2	Y-12	1,102,135
1983	JXI-FZB	2	Y-12	517,913
1984	(JXI-FZF)			
	(JXI-FZB	11	Y-12 2,868,215)	
	(JXI-AUA	3	LANL 167,606)	3,035,821
1985	-	-	-	-
1986	JXI-FZF	4	Y-12	955,115
1987	-			
1988	-			
1989	-			
1990	-			
1991	-			
1992	-			
1993	JXI-FZF	1	Y-12	116,496
1994 - 1997	-	-	-	-
1998	JXI-FZF	2	Y-12	424
Product inventory currently stored at INEEL			1,770,061	
			TOTAL	32,005,353

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
1.	2/53 - 8/53	Hanford C and J Slugs	275.33	Aluminum	275.33
2.	10/53 - 12/53	MTR, LITR, NRX Aluminum Clad, Declad EBR-I in Aluminum Can	65.95	Aluminum	65.95
3.	7/54 - 2/55	Declad EBR-I in Al can. NPR, MTR, LITR, Borax, Hanford C and J Slugs	645.35	Aluminum	645.35
4.	3/55 - 11/55	Hanford J Slugs, MTR, Borax, LITR, SRP Reject Slugs	667.34	Aluminum	667.34
5.	12/55 - 3/56	Hanford C and J Slugs, SRP Reject Slugs	581.13	Aluminum	581.13
6.	3/56 - 5/56	MTR, LITR, CP-3, CR, Borax	30.83	Aluminum	30.83
7.	5/56 - 3/57	Hanford C and J Slugs, CR, MTR, Borax, LITR, ANL, SRP LM Slugs	956.20	Aluminum	970.38
		Zirconium	11.57	Zirconium	
		RaLa MTR	2.61	RaLa	
8.	10/57 - 12/57	SRP LM Slugs	467.00	Aluminum	467.20
		RaLA MTR	0.20	RaLa	
9.	12/57 - 1/58	Zirconium	15.00	Zirconium	15.00
10.	1/58 - 2/58	Hanford C Slugs	276.50	Aluminum	277.20
		RaLa MTR	0.70	RaLa	

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
11.	5/58 - 11/58	SRP LM Slugs, SRP Tubes, MTR, Chalk River	2226.53	Aluminum	2228.70
		RaLa MTR	2.17	RaLa	
12.	12/58 - 4/59	SRP Slugs, SRP Tube, NRX	653.15	Aluminum	653.99
		RaLa MTR	0.84	RaLa	
13.	4/59 - 8/59	SRP Tube, SRP Slugs, SRP Tube Ends, Chalk River	1174.60	Aluminum	1174.60
14.	7/59 - 12/59	Zirconium	58.30	Zirconium	88.64
		OMRE, BMI	28.50	Aluminum	
		RaLa MTR	1.84	RaLa	
15.	12/59 - 2/60	MTR, ETR, LITR, Convair (ASTR), Hanford C, J and KW Slugs, SRP LM Slugs	779.90	Aluminum	780.23
		RaLa MTR	0.33	RaLa	
16.	2/60 - 3/60	Zirconium	48.00	Zirconium	48.50
		RaLa MTR	0.50	RaLa	
17.	3/60 - 4/60	Zirconium	27.00	Zirconium	27.17
		RaLa MTR	0.17	RaLa	
18.	1/61 - 2/61	ETR	45.10	Aluminum	45.10

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
19.	12/61 - 2/62	MTR, ETR, Borax IV, Hanford C and J Slugs, LITR, Chalk River, CP-5, LPTR, Convair (GTR), OWR, SL-1 Scrap	647.38	Aluminum	651.89
		RaLa, MTR	4.51	RaLa	
20.	6/63 - 9/63	MTR, ETR, SPERT, GETR, BRR, SL-1, BNL, LITR, CP-5, LPTR, Convair (GTR), OWR, WTR, Borax III, Suzie, Hanford AEC and REY, NRU	757.25	Aluminum	758.92
		RaLa MTR	1.67	RaLa	
21.	6/64 - 12/64	BGRR, NRX, McMasters, NRU, NRL, SWE, IRL, U of Mich, FNR, GTR, MTR, OWR, LPTR, LITR UF, ETR, CP-5, Zirconium, SPERT NASA,	504.69	Co-processing Aluminum/Custom	1228.53
		Zr Scrap, PWR Core 1/Seed 1, Zr EBR-I Core 3, SNAPTRAN 2/10A-3 Core Debris	723.84	Co-processing Zirconium	
22.	4/65 - 6/65	VBWR, Al UO_2SO_4	44.60	Aluminum/Custom	44.60
23.	12/65 - 1/66	ATR, MTR, ETR, SPERT, LITR, LPTR, OWR, GTR, ASTR, GETR, EBR-II Vycor Glass Molds, EBR-I Mark II, Plastic Coated Al Fuel Plates	526.96	Aluminum/Custom	526.96

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
24.	3/67 - 9/67	JRR-2/Core 1, NRX, NRU, BGRR, EBR-II Vycor Glass, JRR-2/Core 2, Core 3	62.82	Aluminum/Custom	62.82
25.	4/68 - 6/68	MTR, WSU, ETR, LITR, LPTR, OWR, GTR, CP-5, SER, IRL, GETR, NRL, Graphite, EBR-II Vycor Glass Fuel Molds	698.37	Aluminum/Custom	715.62
		Zr	17.25	Zirconium	
26.	8/69 - 10/69	Zr, SNAPTRAN 2/10 - 2 Debris	468.56	Co-processing Zirconium	1870.26
		MTR, ETR, GETR, Korean, SER, LITR, AFNETR, JRR-2, KUR, LPTR, OWR, ATR, SPERT, ZPR-III	1401.70	Aluminum/Custom	
27.	2/71 - 7/71	Zr	804.00	Zirconium	840.70
		JRR-2, EBR-II Scrap, WADCO	36.70	Custom	
28.	6/72 - 8/72	Zr	206.0	Co-processing Zirconium	361.56
		ETR, Custom Miscellaneous	155.56	Aluminum/Custom	
29.	1/73 - 5/73	EBR-II	1546.60	Stainless/ Electrolytic	1546.60
30.	2/74 - 5/74	Zr	637.20	Co-processing Zirconium	1693.59

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
		GETR, ATR, MTR, JRR, ETR, CP-5, OWR, JMTR, Juggernaut, KUR, UM, SER, LPTR, EBR-II Vycor Glass, GGA Thermionic, U of WY. Al Fission Disc, HTRE Scrap, Walter Reed Army Hospital, Nuclear Test Gauge. HTGR Ash, BMI Fission Disc	1056.39	Aluminum/Custom	
31.	2/75 - 5/76	EBR-II	3139.80	Stainless/ Electrolytic	3139.80
32.	5/76 - 9/76	Zr, PWR	564.6	Zirconium	564.6
33.	3/77 - 6/77	Godiva, HTRE, ATR, MTR, LPT, ETR, GETR	655.22	Aluminum/Custom	655.22
34.	8/77 - 9/77	EBR-II	390.60	Stainless/ Electrolytic	589.84
		MORE, SPERT, ORNL 17-1, BMI Fission Disc, Kinglet, Godiva, PBF Metallurgical Samples	199.24	Aluminum/Custom	
35.	7/78 - 3/79	Zr	342.40	Zirconium	377.00
		Custom (Misc)	34.60	Custom	
36.	9/80 - 3/81	Zr	706.10	Co-processing Zirconium	1356.54

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
		Rocky Flats U_3O_8, GETR, OWR, STIR, LPTR, UCLA-MTR, ATR, ETR	650.44	Aluminum/Custom	
37.	8/81 - 11/81	EBR-II	826.00	Stainless/ Electrolytic	981.00
		Los Alamos Metal Fuel Scrap, Rocky Flats U_3O_8,	155.00	Custom	
38.	9/82 - 11/81	ETR, BSR, ATR, OWR, ORR, HFR-Petten, SAPHIR, GETR, FRG, FRJ/FRM, SFR, LANL UO_2SO_4,	417.17	Aluminum/Custom	417.17
39.	4/83 - 6/84	Rover	3027.60	Rover	3311.00
		Godiva, Rocky Flats U_3O_8, Fluorinel Startup	219.50	Custom Fluorinel Zirconium	
40.	8/85 - 1/86	ITAL, FRG, DR-3, UCLA, MURR, OWR, HFBR, LPTR, TR-1, ATR, BSR, ORR, HMI, TRITON, FRJ-2, HFR, BR-2, ORPHEE, ASTRA, SFR, R-2, JUNTA, McMaster Univ., JRR-2, JMTR, JANUS, SR, UCSB UO_2SO_4	722.91	Aluminum/Custom	725.11
		Fluorinel Startup	2.20	Fluorinel	
41.	10/86 - 10/87	Fluorinel	809.70	Fluorinel	809.70
42.	12/87 - 7/88	Fluorinel	670.70	Fluorinel	960.20

Table V
Fuel Processed at ICPP

Number	Date	Fuel Type	U Kgs	Process	Total U Kgs
		EBR-II Vycor Glass Molds, BYU UO_2SO_4, EBR-II Fuel Scrap, ANL-E Fuel Scrap	289.50	Custom	
		TOTAL U Charged			33231.87